LA-UR-18-28889
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Title: Commercialization Opportunity SFAI: An acoustic-based method for measuring composition and flow in containers, vessels, and pipes

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Intended for: Report

Issued: 2018-09-19

Los Alamos National Laboratory

Commercialization Opportunity

SFAI: An acoustic-based method for measuring compositions and flow in containers, vessels, and pipes

POTENTIAL AREAS FOR **PARTNERSHIP**

The need to accurately discern the characteristics of materials within closed containers non-invasively is a problem that plagues many industrial sectors. In particular, characterizing multi-phase flow in pipes and other infrastructure is an ongoing challenge for many industries. Swept Frequency Acoustic Interferometry, or SFAI, and related technologies represent a portfolio that uses high-frequency sound to characterize liquids, gasses, mixtures, emulsions, and other fluids inside pipes and containers. SFAI offers the potential to measure material characteristics and two-and three-phase flows within pipes including flow rates and water- and gas-volume fractions. Such measurements can take place noninvasively both in accessible infrastructure and potentially downhole.

INDUSTRY **MARKET SECTORS**
1. Upstream Oil and Gas
2. Medical Diagnostics
3. Downstream Oil and Gas
4. Chemical and Pharmaceutical Industries
5. Agricultural and Food Industries
6. Geothermal and Biofuel Energy

KEY **HIGHLIGHTS** OF THE **SFAI PORTFOLIO**

OIL AND GAS APPLICATIONS OF SFAI

The SFAI portfolio has a wide-range of potential applicability in both upstream and downstream environments. SFAI uses chirp-signal propagation (wideband ultrasonic frequency) through a multiphase medium to extract frequency-dependent physical properties of the medium. Users then use the propagation time and the attenuation of the chirp signal as a function of frequency to extract both fluid flow and multiphase-fluid-composition information (oil/water/gas cut). Applications have been tested in real oilfield environments for two-phase flow and are in development for three-phase flow. Measuring solids within flowing fluids is also possible. Calibration of SFAI instruments is relatively simple. SFAI has been tested at low-gas cuts with potential to develop for high-gas cut scenarios. SFAI's ability to provide accurate, real-time volumetric measurements of oil flow from wells means (1) better reservoir management through production tuning and (2) cost savings, as it is no longer necessary to use environmentally unsafe separations tanks to make such measurements. Similar techniques are applicable to measuring operational flows in downstream environments.

BENEFITS:

- Provides noninvasive, continuous real-time and accurate estimates of oil production in individual wells. Measurements can be made in less than one-second; this is much faster than current practices in the industry.

- Simple and inexpensive. Eliminates the need for separation tanks and Coriolis meters.

- Effective for both free-flowing wells and those using artificial lift (rod pumps, submersible pumps, etc.).

- Minimizes environmental impacts, such as fugitive gas emissions, spills, and large separation tank footprints, associated with current fluid sampling practices

MEDICAL APPLICATIONS OF SFAI

The SFAI portfolio also has a range of potential application areas in the medical field, although these applications are not as well-developed as those in the field of oil and gas. Most medical applications would require extensive technology development and clinical testing. Potential applications include: 1) *in-situ* sensing of bodily vital signs such as blood viscosity, composition, and density; 2) measurement of intracranial pressure; 3) monitoring of fluid drips in patients to ensure quality control; 4) real-time monitoring of blood during procedures such as transfusions.

BENEFITS:

- Provides noninvasive, rapid and accurate measurements of fluid compositions on the small sample sizes characteristic of medical diagnostics. Non-invasive sampling minimizes potential contamination.
- Systems for medical applications can be very simple and inexpensive.
- Minimization of fluid handling might allow deployment in clinical settings in remote environments (military deployments, underdeveloped countries).

OTHER INDUSTRIAL APPLICATIONS OF SFAI

Many other industries also require measurement of materials inside containers and/or pipes and currently use slow, expensive *ex-situ* sampling methods of process streams where real-time *in-situ* sampling using SFAI would save money and improve product quality. Such industries include the chemical industry, the pharmaceutical industry, and the food and agricultural sectors. All of these industries utilize flowing process streams where real-time monitoring might improve operations by reducing time-frames for analysis, minimizing the potential for contamination, and reducing costs. Other energy sectors (beyond

oil and gas) with business cases for SFAI include the geothermal industry (for measuring geothermal fluids downhole or topside) and the biofuels industry (for measuring algae slurry production parameters). In static (non-flow) environments SFAI can easily identify fluids in closed containers such as for airport screening applications or in abandoned drums or military materials. Like the medical applications of SFAI, most of these applications would also require significant development efforts.

BENEFITS:

- Customizable to specific industrial process-flow systems and closed-container applications.
- Rapid analysis time should allow for improved process control; coupling with artificial intelligence tools may lead to real-time feedback-loop implementation.
- Reduced environmental and personnel risks associated with *ex-situ* sampling. Minimizes potential spills and personnel exposure to hazardous environments.

LANS INTELLECTUAL PROPERTY

Available for non-exclusive and/or exclusive licensing or development under a cooperative research and development act agreement (CRADA). Licensing and/or CRADA development likely to be in specific fields of use. Related foreign cases available in a subset of cases. However, due to the on-going costs of maintaining the foreign portfolio, portions may lapse or become abandoned during 2019 if no agreements including such portions have been completed.

S-97,730 "NONINVASIVE CHARACTERIZATION OF A FLOWING MULTIPHASE FLUID USING ULTRASONIC INTERFEROMETRY". U.S. Patent 6,644,119 issued 11/11/2003.

S-100,658 "NONINVASIVE CHARACTERIZATION OF A FLOWING MULTIPHASE FLUID USING ULTRASONIC INTERFEROMETRY". U.S. Patent 6,889,560 issued 5/10/2005.

S-100,659 "NONINVASIVE CHARACTERIZATION OF A FLOWING MULTIPHASE FLUID USING ULTRASONIC INTERFEROMETRY". U.S. Patent 6,959,601 issued 11/01/2005.

S-104,906 "NONINVASIVE CHARACTERIZATION OF A FLOWING MULTIPHASE FLUID USING ULTRASONIC INTERFEROMETRY". U.S. Patent 7,228,740 issued 6/12/2007.

S-109,074 ''NON-INVASIVE FLUID DENSITY AND VISCOSITY MEASUREMENT". U.S. Patent 8,166,801 issued 05/01/2012.

S-118,927 "INTEGRATED ACOUSTIC PHASE SEPARATOR AND MULTIPHASE FLUID COMPOSITION MONITORING DEVICE". U.S. Patent 8,640,529 issued 02/04/2014.

S-121,335 "METHOD FOR NONINVASIVE DETERMINATION OF ACOUSTIC PROPERTIES OF FLUIDS INSIDE PIPES". U.S. Patent 9,404,890 issued 08/02/2016.

S-121,336 "NON-INVASIVE MULTI-PHASE FLUID CHARACTERIZATION SYSTEM". U.S. Patent 8,820,147 issued 09/02/2014.

S-121,245 "METHOD FOR NONINVASIVE SOLID PARTICLE DETECTION USING DOPPLER SPECTROSCOPY". U.S. Patent 9,354,094 issued 05/31/2016.

S-121,246 "APPARATUS AND METHOD FOR VISUALIZATION OF PARTICLES SUSPENDED IN A FLUID AND FLUID FLOW PATTERNS USING ULTRASOUND". U.S. Application 20120227473 published 09/13/2012.

S-133,084 “METHODS FOR MEASURING PROPERTIES OF MULTIPHASE OIL-WATER-GAS MIXTURES”. U.S. Application 20160041286 published 02/11/2016.

S-133,154 “INTEGRATED ACOUSTIC PHASE SEPARATOR AND MULTIPHASE FLUID COMPOSITION MONITORING APPARATUS AND METHOD”. U.S. Patent 9,234,779 issued 01/12/2016.

S-133,273 “ULTRASONIC IN-SITU WATER-CUT MEASUREMENT USING ULTRASONIC OIL-WATER SEPARATION FOR AFFECTING SOUND SPEED CALIBRATION”. U.S. Application 20180088083 published 03/29/2018.

S-133,274 “ACOUSTIC GAS FRACTION MEASUREMENT IN A MULTIPHASE

FLOWING LIQUID". U.S. Application 20180120269 published 05/03/2018.

S-133,322 "NONINVASIVE ACOUSTICAL PROPERTY MEASUREMENT OF FLUIDS". P.C.T. Application WO2018/017902 published 01/25/2018.

S-133,613 "SWIFT – LOW COST MULTIFUNCTION OIL/WATER/GAS METER" To be filed.

U.S. Non-Exclusive Patent Rights only:

S-91,733 "APPARATUS AND METHOD FOR REMOTE, NONINVASIVE CHARACTERIZATION OF STRUCTURES AND FLUIDS INSIDE CONTAINERS". U.S. Patent 6,186,004 issued 02/13/2001.

S-94,727 "CYLINDRICAL ACOUSTIC LEVITATOR/CONCENTRATOR". U.S. Patent No. 6,467,350, issued 10/22/2002.

S-99,930 "CYLINDRICALACOUSTICLEVITATOR/CONCENTRATOR HAVING NON-CIRCULAR CROSS-SECTION". U.S. Patent No. 6,644,118, issued 11/11/2003

S-109,031 "NON-CONTACT FEATURE DETECTION USING ULTRASONIC LAMB WAVES". U.S. Patent 7,963,165 issued 06/21/2011.

S-109,068 "NON-CONTACT FLUID CHARACTERIZATION IN CONTAINERS USING ULTRASONIC WAVES". U.S. Patent 8,176,783 issued 05/15/2012.

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PREFERRED **PARTNER ATTRIBUTES**

- Demonstrated knowledge of product marketing, sales, and worldwide product distribution.

- Technology commercialization strategy and business plan (e.g., in-house development, partnering with industry leaders, sublicensing, etc.)
- Financial and human resources to be dedicated to this commercialization effort.
- Established experience with product research and development in the industrial sector chosen for product development (e.g. oil and gas, medical).
- Ability and willingness to financially support the extensive SFAI patent portfolio (US and selected foreign).
- Expertise in one or more of the following: acoustics, ultrasonics, signal processing, and product development/engineering plus extensive experience in the industry sector chosen for commercialization.
- Proven technical and customer support model.
- One or more U.S. executives with whom LANS personnel may interact; preference for U.S. companies.
- Ability and willingness to ensure compliance with U.S. Export Control law is a requirement.

WHAT WE ARE **REQUESTING**

Please submit a written response on how your organization envisions utilizing and deploying this technology in partnership with Los Alamos. We look forward to reviewing your ideas on how we can together bring the SFAI portfolio to the private sector; we anticipate entertaining several partners in different industry sectors. Please respond by email to dhickmott@lanl.gov, or call Donald Hickmott directly at (505) 667-8753 by November 1, 2018 although responses will be considered until the technology is fully licensed.

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